Romulus I: 16-Bit CPU

The Generational Divide between Professors and Students

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

It is no secret that there are implicit biases present in classrooms that make schoolwork easier for some students compared to others. Studies have shown that universities are typically very liberal institutions, which can make more conservative leaning students, as well as religious students, feel like they do not belong at the university (Wills et al., 2019). This can lead to negative classroom experiences and create tension between professors and students that negatively affect the learning process. Studies, like the one performed by Wills et al., make it clear that teachers and professors need to put in extra effort to ensure that their classroom is as accessible as possible to students of all backgrounds.

There are many different strategies that professors can use to ensure that students are able to get the most out of their classes. One strategy suggested by Professor Breanna Boppre is to make the most use out of experiential learning (Neuhaus, 2022). According to Boppre, there are four main steps in the experiential learning process, namely: "(1) the experience itself, (2) observation and reflection, (3) assimilation of the experience into abstract concepts and knowledge, and (4) conceptualization to guide future experiences" (p. 102). This method of teaching involves exposing students to topics in multiple ways, providing a better chance for each student to find an approach that compels them to want to learn. This process also helps students to connect what they learn in the classroom to their real-world experiences. There is similar thinking in the computing pedagogical world when it comes to teaching abstract concepts. In the third chapter, "Keeping it Real," of *Inclusive Computing Education in the Secondary School: Linking Theory and Practice*, there is a similar emphasis on presenting and engaging with material in different ways to be inclusive in teaching (Louise & Overland, 2023).

This chapter also shows the benefits of having concrete examples and analogies of more abstract topics that are common in computing courses.

This approach to teaching, along with the documented difficulties students have understanding solid state devices like modern computer processing units (CPUs) (Rahman et al. 2014), is what the subsequently mentioned technical project will address. This project is a relatively simple 16-bit CPU with many features to visually convey how the CPU works to solve the tasks given to it. This can be used as a tool to provide students with a different experience to normal lectures, as well as a way to concretely see how computers work to process information, instead of the usual abstract way.

The sociotechnical topic this paper will discuss relates to the implicit biases present between students and professors that has been briefly discussed. Specifically, this paper will investigate the almost certain difference between professors and students, being that they have had different life experiences from growing up in different generations.

This project and exploration of biases that will frequently be present could possibly open a space for technology to help close the gap between professors and students. They will both explore methods to make teaching more accessible to as many students as possible.

Romulus-I : 16-Bit CPU

Romulus-I is the name of the 16-bit CPU that is being constructed to help provide a more accessible way to approach teaching about computers, by having many different indicators that show how data is being moved around the CPU and what is being done to it in order to perform operations. The goal is for this technology to be used by professors in class to visually show how

computers execute instructions, as well as having an online simulator version that will allow students to individually experiment and complete assignments with.

Using an older CPU design with many more indicators will make the process easier to understand than modern CPUs, which are all tiny and cannot be followed around. The goal is to have indicators similar to the ones found on IBM calculating machines (Aiken et al., 1964). This process of building small CPUs is viable and has been done in similar ways such as Eater's 8-bit CPU (2016).

Romulus-I has its own Instruction Set Architecture (ISA), which are the possible operations it can perform. These operations are chosen specifically so that the hexadecimal machine code instructions are easy to read and understand simply by looking at them. This is due to the fact that each hexadecimal character in the machine code directly corresponds to either the operation to be performed or what to use to perform the operation. This ISA has the same basic capabilities as a Turing machine and has a Turing complete instruction set. It offers all required reading and writing functionality, basic operations such as addition, subtraction, and shifts, as well as the ability to jump to different locations in the code.

These instructions will be able to be visually followed around the CPU, because there are many LEDs and 7-segment displays that show relevant information for each instruction such as, what machine code is currently being executed, what data is being shared between components, and what data is stored in various registers. To make it easy to follow, the speed at which the computer runs is configurable to be as fast as possible down to being able to step between each state the computer enters using a button. The LEDs and other displays are also toggleable, so that they do not have to be activated if you choose to run at high speeds.

The Romulus-I will have 4 input/output slots in order to connect and use peripheral devices alongside the Romulus-I. The location of the driver code (which tells the CPU what to do with input from the peripheral) for these peripherals will be in the same instruction space as the rest of the code and the address of the driver can be set using a DIP switch.

Coding instructions for the Romulus-I also will be supported with an assembly language that will generate the correct machine code to perform instructions specified. This will make coding the Romulus-I more accessible and make the purpose of the code clearer with a quick glance.

Alongside the physical Romulus-I, a simulation version that functions the same as the physical version will be constructed. This could allow students to complete homework assignments using a virtual version of a machine they used to learn with in class, or simply allow students to interact with and experiment with it on their own.

The Generational Divide between Professors and Students

How do generational differences in approaching problems and the world affect the classroom environment? The difference in generation between professors and students is almost always present, because professors are typically older than their students. As expected, being older and more experienced qualifies an expert on a topic who can teach the subject. Students have had different experiences from their professors which have shaped them to view the world differently and can cause disconnects in the classroom.

The most obvious difference stems from the experience that professors have compared to students. In a study performed by Conde and Clemente-Suarez, they looked at how both medical students and professors perceived stress and difficulty while performing various clinical

observations (2021). It was found that students generally thought each clinical was more stressful and difficult as opposed to the professors, as well as performing worse on them. Conde and Clemente-Suarez found that student training programs could be changed to help improve perceptions in students who generally display a lack of self-confidence in their work.

This lack of self-confidence partly comes from lack of experience, but also from the general perception of Generation Z that being successful in achieving your goals is more difficult than how previous generations perceived being successful (Strom & Strom 2021). The research done by Strom & Strom "describes the priority goals and main concerns of five generations in the United States" (2021 p. 184). This research shows that the differences in what each generation is concerned with are rather large, which can lead to misunderstandings as to why members of other generations act the way they do. A case study by Wysmułek & Wysmułek looks at different generational groups that grew up in wildly different environments in Poland, and how their experiences at a young age shape their outlook on meritocracy (2024). Meritocracy can be defined as a society who selects and rewards people based on their own merits. The perceived meritocracy that was observed in this case study looked at how much people thought talent, motivation, and hard work could overcome corruption and nepotism. They found that the environment that people grew up in shaped their views, regardless of any of the chaos they experienced later in life. The generation that was young during the most chaotic reign of Poland had the least fond views of meritocracy, even though the older generation who lived through the same experiences had the fondest views of meritocracy. This shows that although professors have lived through the same times as the current generation of students, there is a difference in the magnitude of how much events have affected professors compared to students.

This difference is important to discuss and research further, because the way that different generations need to be taught effectively is different. Professors have been shown to agree that pedagogy needs to change to adapt to Generation Z, but also that few professors have taken steps to change their teaching methods (Barreiro et al., 2017). While professors know there are issues with reaching the current generation, they do not know how to approach solving the problem.

To obtain a greater understanding of where these differences come from, an Actor Network Theory (ANT) analysis focusing on the events, technologies, and ideologies that were present and influential in both Generation Z and the average professor generation, Generation X, will be performed. An ANT analysis looks at a topic and examines how different 'actors' interacted with each other and the topic to show how it came to be. This will allow an understanding of the differences of values to be gained and allow a similar ANT analysis on the future generation, Generation Alpha, to allow us to predict what future difficulties will come when teaching the next generation, allowing for potential solutions to be created before the problems even exist.

Conclusion

This paper has explored the implicit biases present in classrooms due to the inherit differences between students and professors. The goals of both Romulus-I, the 16-bit CPU, and the research into how generational differences affect the relationship between students and professors are to help make the classroom the best learning experience for a greater number of students. Additionally, it is possible for pieces of technology to aid in filling in the gaps between students and professors. There is potential for devices similar to the Romulus-I to help build connections between students and professors because they appeal to both groups for different

reasons but provide a common ground for connection. Technology provides many opportunities to experience topics differently, making technology both a way to provide a more equitable learning environment and build connections between students and professors.

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